Global Information Assurance Certification Paper

UNSPOKEN TRUTHS – FORENSIC ANALYSIS OF AN UNKNOWN BINARY (GIAC v1.4)

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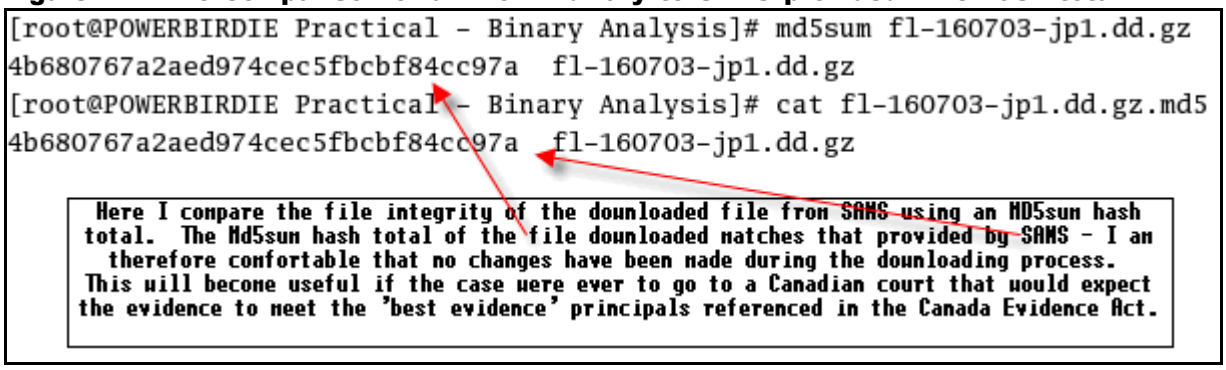
Background:

The first component of this paper outlines my forensic analysis of an unknown binary that is contained within a zip file provided by SANS[1] (http://www.giac.org/gcfa/binary_v1_4.zip), as such I have decided to take some precautionary steps for the first stages of the analysis. To ensure that the unknown binary will not affect a whole system (i.e. corrupt the machine), I will be using a Linux 9.0 VMware session running on one of my forensic laptops.

Since the binary is unknown, I do not want to simply unzip the binary without taking some precautionary steps first. Upon downloading the unknown binary I immediately performed an MD5Sum on the file as received from SANS. This will enable me to ensure the file integrity and completeness once transmitted to the air-gapped forensics box.

Figure 1.1 MD5 comparison of unknown binary to SANS provided MD5 hash total

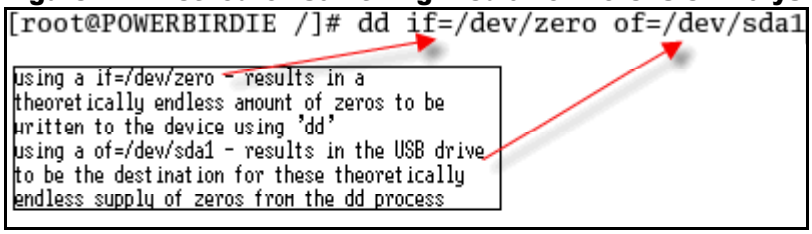


To transfer the files from my networked machine to the air-gapped one, I am using a USB Drive ™ 128 Mb – USB memory stick with serial # E-D900-00-4989(B). This will also be used to collect evidence of the forensic procedures undertaken, and transfer it to a networked machine for report writing and retention.

Media Preparation:

As a standard practice before beginning any forensic analysis[2], to ensure that the media is cleansed from previous evidence; I used the 'dd' utility within Linux to write the complete contents of the USB device with a string of zeros. In theory by dd'ing a device with an image source of /dev/zero the forensic analyst is copying an unlimited source of 'zeros' to the destination media.

Figure 1.2 Method of Sanitizing Media for Forensic Analysis



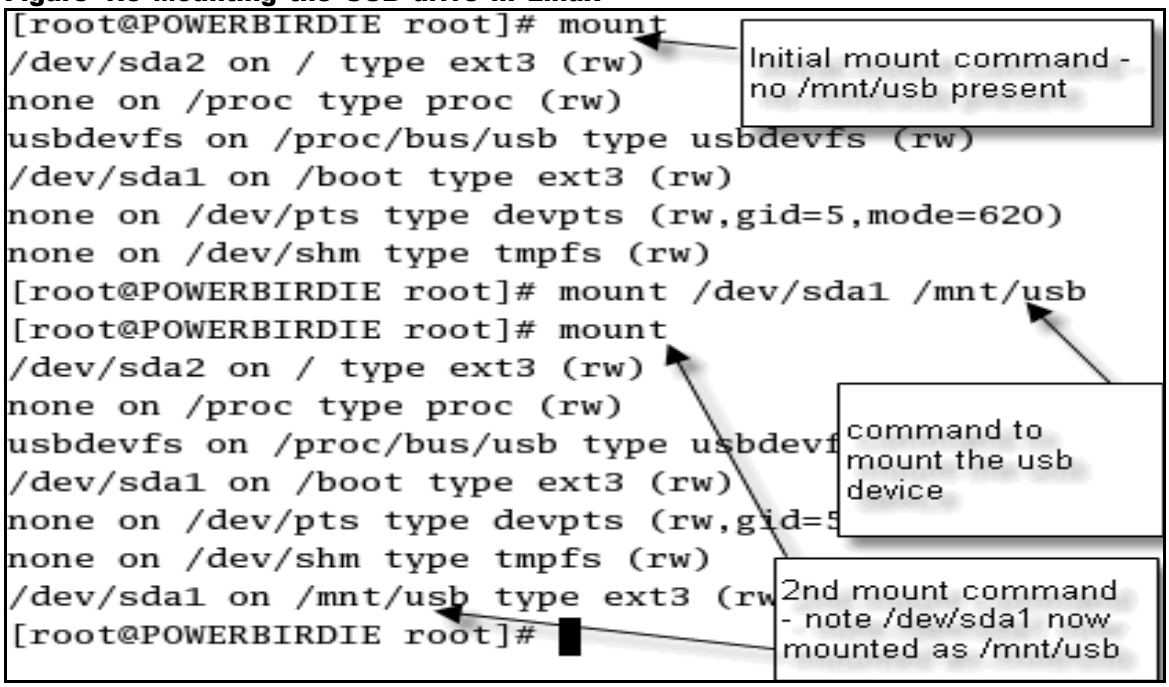
[1] See Appendix D for more details

[2] I ensure that the media used for any forensic analysis is cleansed prior to use – as this step ensures that the evidence is admissible and in keeping with the 'best evidence' requirements within the Canadian Evidence Act. (http://laws.justice.gc.ca/en/C-5/)

If this analysis were being done on a Windows machine, an additional low level format prior to using a ported version of 'dd' from a command line would be appropriate (if an investigator has a machine with EnCase installed this step can be completed using the 'wipe drive' option). While not required it is an old habit which provides an additional level of comfort that no residual evidence is present.

As I am using my Linux forensic machine (see **Appendix C** for a complete description of the equipment used.) for this analysis, I will mount the USB device (**/dev/sda1**) as mount point **/mnt/usb/** using the following command:

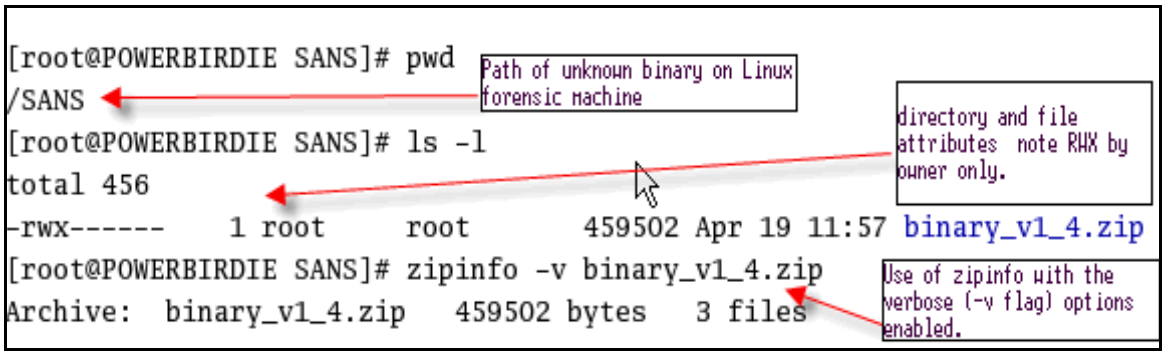
Figure 1.3 Mounting the USB drive in Linux



Setting the Stage – The Known Information:

Initially I have used the zipinfo utility with the –v flag. This utility provides us with a significant amount of data about contained within the file binary_v1_4.zip provided to me by SANS, however does not require me to extract the files. This utility can be very helpful to in gathering important information while preventing the extraction of possible malicious code.

Figure 1.4 File Ownership and Zipinfo commands against unknown Binary



Extract of zipinfo –v command: (I choose italicized blue text for any extracted text from the analysis)

Archive: binary_v1_4.zip 459502 bytes 3 files

```
End-of-central-directory record:
--------------------------------

  Actual offset of end-of-central-dir record:     459460 (000702C4h)
  Expected offset of end-of-central-dir record:   459460 (000702C4h)
  (based on the length of the central directory and its expected offset)

  This zipfile constitutes the sole disk of a single-part archive; its
  central directory contains 3 entries.  The central directory is 227
  (000000E3h) bytes long, and its (expected) offset in bytes from the
  beginning of the zipfile is 459233 (000701E1h).

  The zipfile comment is 20 bytes long and contains the following text:

======================== zipfile comment begins
==========================
GCFA binary analysis
========================= zipfile comment ends
==========================

Central directory entry #1:
---------------------------

  fl-160703-jp1.dd.gz

  offset of local header from start of archive:    0 (00000000h) bytes
  file system or operating system of origin:       Unix
  version of encoding software:                  2.3
  minimum file system compatibility required:      MS-DOS, OS/2 or NT
FAT
  minimum software version required to extract:    2.0
  compression method:                            deflated
  compression sub-type (deflation):                 normal
  file security status:                          not encrypted
  extended local header:                         no
  file last modified on (DOS date/time):           2003 Jul 15 23:03:02
  file last modified on (UT extra field modtime):  2003 Jul 16 02:03:01
local
  file last modified on (UT extra field modtime):  2003 Jul 16 05:03:01
UTC
  32-bit CRC value (hex):                         037deebe
  compressed size:                               458937 bytes
  uncompressed size:                             474162 bytes
  length of filename:                            19 characters
  length of extra field:                         13 bytes
  length of file comment:                        0 characters
  disk number on which file begins:                disk 1
  apparent file type:                            binary
  Unix file attributes (100400 octal):              -r--------
  MS-DOS file attributes (01 hex):                 read-only

  The central-directory extra field contains:
  - A subfield with ID 0x5455 (universal time) and 5 data bytes.
    The local extra field has UTC/GMT modification/access times.
  - A subfield with ID 0x7855 (Unix UID/GID) and 0 data bytes.
```

```
  There is no file comment.

Central directory entry #2:
---------------------------

  fl-160703-jp1.dd.gz.MD5

  offset of local header from start of archive:    459007 (000700FFh)
bytes
  file system or operating system of origin:       Unix
  version of encoding software:                  2.3
  minimum file system compatibility required:      MS-DOS, OS/2 or NT
FAT
  minimum software version required to extract:    1.0
  compression method:                           none (stored)
  file security status:                         not encrypted
  extended local header:                        no
  file last modified on (DOS date/time):          2003 Jul 16 00:15:00
  file last modified on (UT extra field modtime):  2003 Jul 16 03:14:59
local
  file last modified on (UT extra field modtime):  2003 Jul 16 06:14:59
UTC
  32-bit CRC value (hex):                        75457d32
  compressed size:                              54 bytes
  uncompressed size:                            54 bytes
  length of filename:                           23 characters
  length of extra field:                        13 bytes
  length of file comment:                       0 characters
  disk number on which file begins:               disk 1
  apparent file type:                           text
  Unix file attributes (100644 octal):             -rw-r--r--
  MS-DOS file attributes (00 hex):                none

  The central-directory extra field contains:
  - A subfield with ID 0x5455 (universal time) and 5 data bytes.
    The local extra field has UTC/GMT modification/access times.
  - A subfield with ID 0x7855 (Unix UID/GID) and 0 data bytes.

  There is no file comment.

Central directory entry #3:
---------------------------

  prog.MD5

  offset of local header from start of archive:    459135 (0007017Fh)
bytes
  file system or operating system of origin:       Unix
  version of encoding software:                  2.3
  minimum file system compatibility required:      MS-DOS, OS/2 or NT
FAT
  minimum software version required to extract:    1.0
  compression method:                           none (stored)
  file security status:                         not encrypted
  extended local header:                        no
  file last modified on (DOS date/time):          2003 Jul 16 00:14:38
  file last modified on (UT extra field modtime):  2003 Jul 16 03:14:38
```

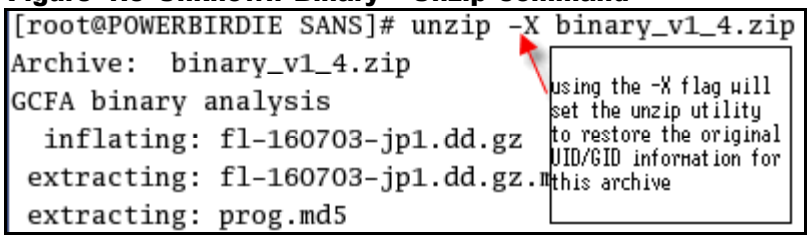
```
local
  file last modified on (UT extra field modtime):   2003 Jul 16 06:14:38
UTC
  32-bit CRC value (hex):                          804cc662
  compressed size:                                39 bytes
  uncompressed size:                              39 bytes
  length of filename:                             8 characters
  length of extra field:                          13 bytes
  length of file comment:                         0 characters
  disk number on which file begins:                 disk 1
  apparent file type:                             text
  Unix file attributes (100644 octal):               -rw-r--r--
  MS-DOS file attributes (00 hex):                  none

  The central-directory extra field contains:
  - A subfield with ID 0x5455 (universal time) and 5 data bytes.
    The local extra field has UTC/GMT modification/access times.
  - A subfield with ID 0x7855 (Unix UID/GID) and 0 data bytes.

  There is no file comment.
```

As we can see this utility tells us that the operating system of the machine used to create this archive is a Unix (likely Linux machine – based on other analysis below), the zip file was last modified on July 16, 2003 and the zip contains **fl-160703-jp1.dd.gz, fl-160703-jp1.dd.gz.MD5, and prog.MD5. The individual file sizes are: 474162, 54, 39** bytes respectively.

Extraction of Unknown Binary:

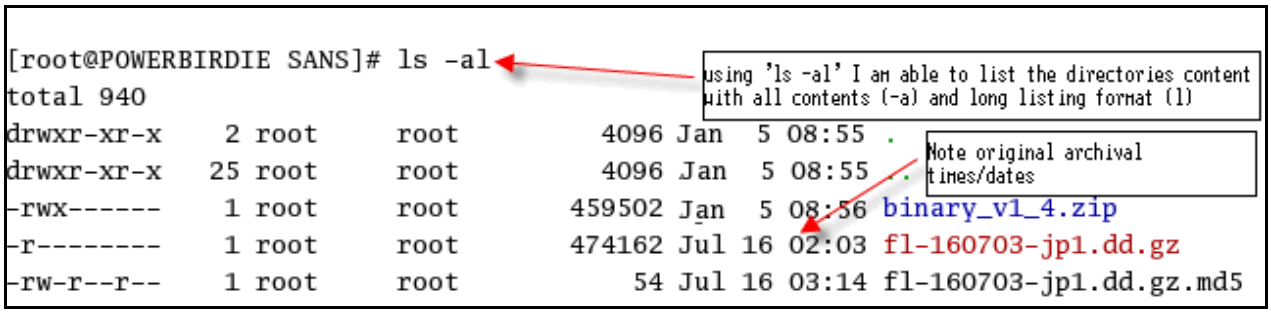
The above analysis indicates that the binary appears to have the adopted the user (UID) and group (GID) attributes of my machine. Using the 'unzip' command with the '–X' flag enabled it might be possible to determine the permissions of the original UID/GID of the files as they were set on the machine prior to archival. This will potentially yield additional information that can be used in piecing together seemingly random case evidence.

Figure 1.5 Unknown Binary - Unzip command



Next the following command 'ls –al' issued to determine the file permissions and timer at archival.

Figure 1.6 Unzipped – Unknown Binary File Permissions



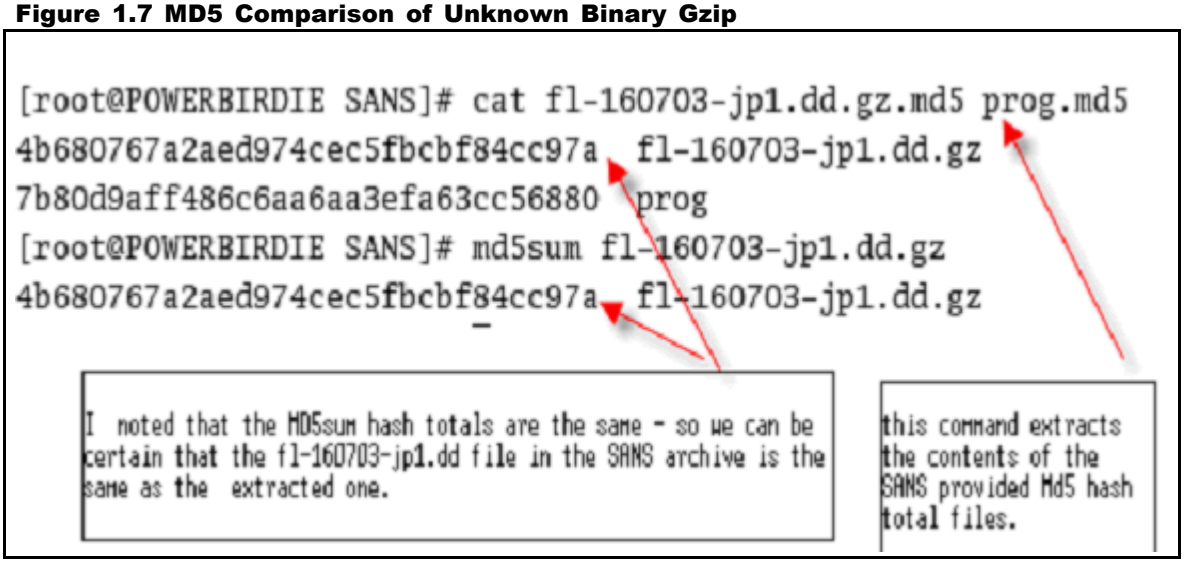
It is interesting to note that the original machine appears to be using a Unix based kernel (based on UID/GID and directory permissions. As a result my expectation is that this unknown binary will be a Unix based binary as opposed to a Windows one. Additionally I noted that the date on the system used for archival was July 16, 2003. This may be important later on as it may help us validate the existence of the binary at that point in time in the general Internet population.

Since I passed the '**–X**' flag to the unzip command my expectation was that the utility would have restored the UID/GID of the original system. Given that the UID/GID are still set to root/root respectively then either the system was a Unix system or the user was logged in as root in a root owned directory when tar'd. It is possible that the file was possibly archived on another system environment - Windows perhaps.

Integrity of the Unknown Binary:

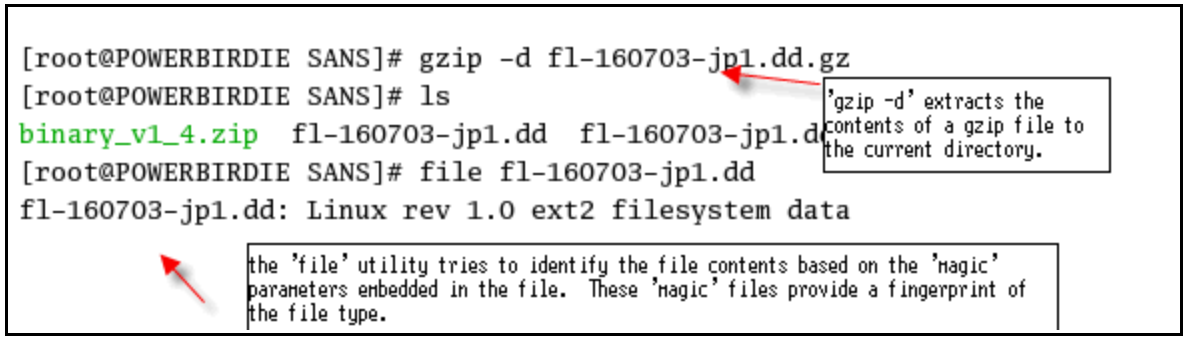
Before I start any analysis on this binary, I will confirm the file integrity using the MD5 hash totals provided by SANS. Since the MD5Sum totals are the same I can state that the binary was not altered between the archival process by SANS, and me extracting it in the forensic lab.

Figure 1.7 MD5 Comparison of Unknown Binary Gzip



I extract the contents of the fl-160703-jp1.dd.gz file with the gzip –d command. The resultant file called fl-160703-jp1.dd appears to be an image created with the Unix '**dd**' utility. We confirm this with the following:

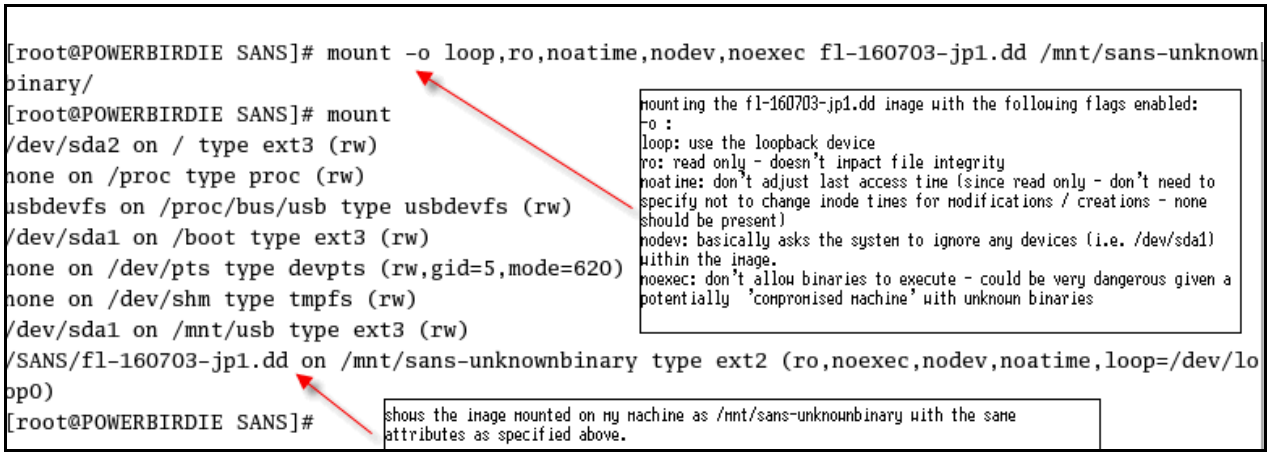
Figure 1.8 Decompress Unknown Binary and 'File' Output



Forensic Analysis Process:

Since the file is a '**dd**' image I have two options to start the analysis; first I can use Autopsy (http://www.sleuthkit.org/autopsy/index.php), or secondly I can mount the image directly in Linux with the command outlined in Figure 1.9. Initially I chose the second option to mount the image directly, however I will also be using Autopsy to perform further do some analysis. I chose this path, as I do not know what to expect, and if the image is mounted properly then no harm will come from the direct mounting.

Figure 1.9 Mounting dd Image in Linux VM Ware



When mounting the image I wanted to ensure that the integrity of the evidence was preserved. By using the following mount options the data integrity will be preserved:

loop – use loopback device
ro – read only so no image changes are allowed
noatime – don't change last access time
nodev – Bypass system devices in image
noexec – disable binary execution

Once mounted I change to that directory and perform an '**ls**' command to list the content of the image and get the following interesting information, namely the '**prog'** file that we have been told to isolate and perform the analysis on as the unknown binary. Typically a forensic analyst doesn't know the exact items they are looking for so this option would be less effective in a real forensic analysis.

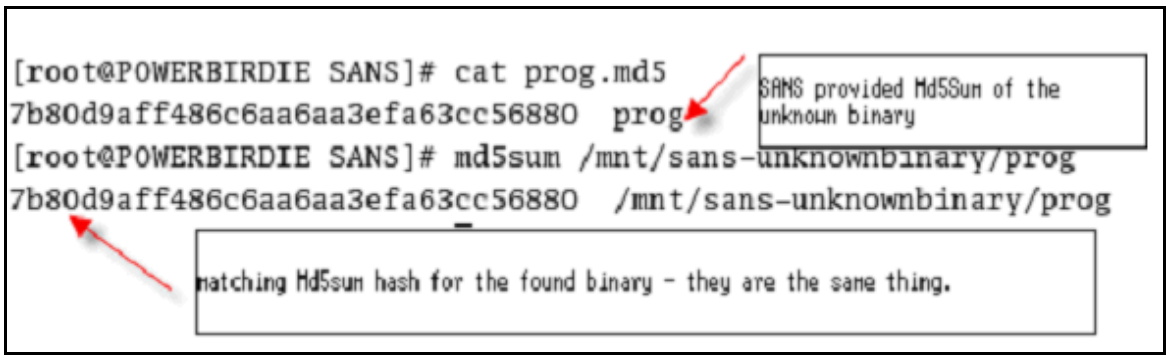
Figure 1.10 Identified Unknown Binary 'Prog'

```
[root@POWERBIRDIE SANS]# cd /mnt/sans-unknownbinary/
[root@POWERBIRDIE sans-unknownbinary]# ls
Docs  John  lost+found  May03  nc-1.10-16.i386.rpm..rpm  prog
[root@POWERBIRDIE sans-unknownbinary]#
```

Is it the Real Thing??:

A quick comparison of the MD5Sum hash totals indicates that this is in-fact the unknown binary.

Figure 1.11 Unknown Binary MD5 Comparison and Match



So we have the 'what' component of the five 'W' questions and at a first glance it appears that we do not have to do anything for me to have been able to extract the unknown binary. As a forensic investigator however, I want to examine all the evidence before making any conclusions. I notice the lost+found directory, and the **nc-1.10-16.i386.rpm** file (this is for a network utility called '**netcat**') were also noted in the '**ls**' output, this might assist / help us to better understand the 'why' and 'where' of any inappropriate activity.

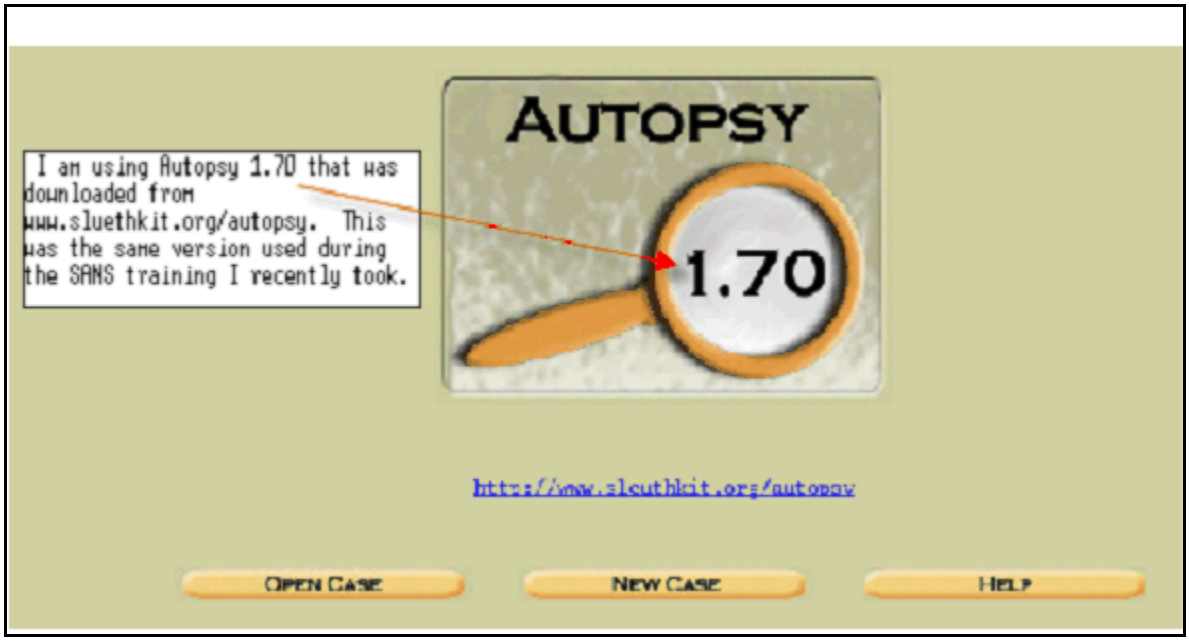
Before going any further I want to load this image into Autopsy and create a timeline as well as other items that I think will help with a thorough investigation.

Autopsy Image Analysis:

To help with the additional analysis of this unknown binary I wanted to perform some additional research in Autopsy[3] (version 1.70). Autopsy is an all-encompassing image analysis tool that draws upon several open source utilities; however the individual tools could also be run independently. In this analysis I choose the New Case icon at the bottom and put in the appropriate investigators name, image type and the source location for the image, as well as the MD5hash total database(s). Autopsy takes this information and starts to assess the timeline (modified, accessed and changed).

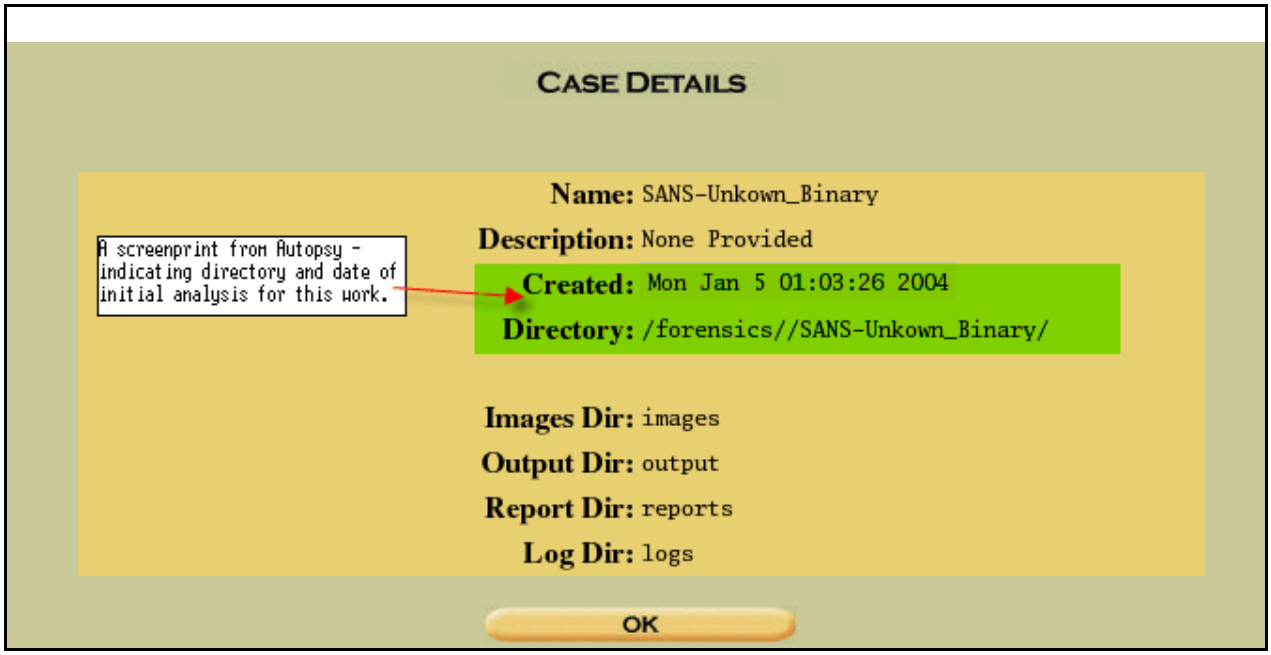
Figure 1.12 SleuthKit – Autopsy Forensic Analysis Tool – Screenshot

[3] Autopsy is located at http://www.sleuthkit.org/autopsy/



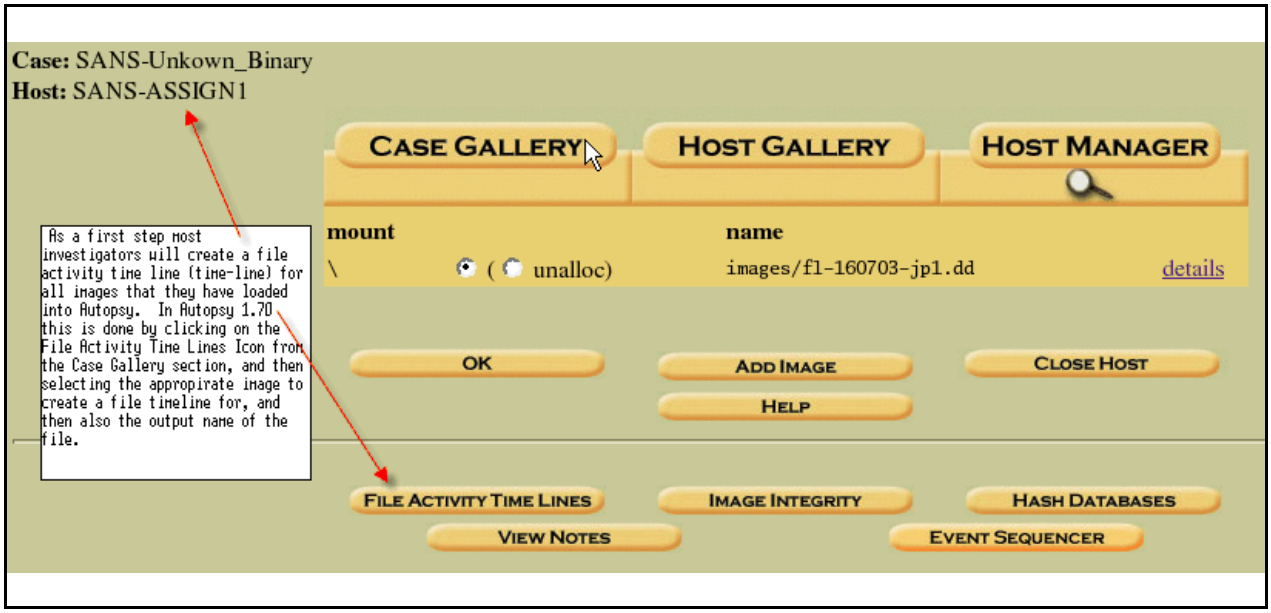
Here are the initial case facts captured in Autopsy:

Figure 1.13 Initial Case Setup within Autopsy



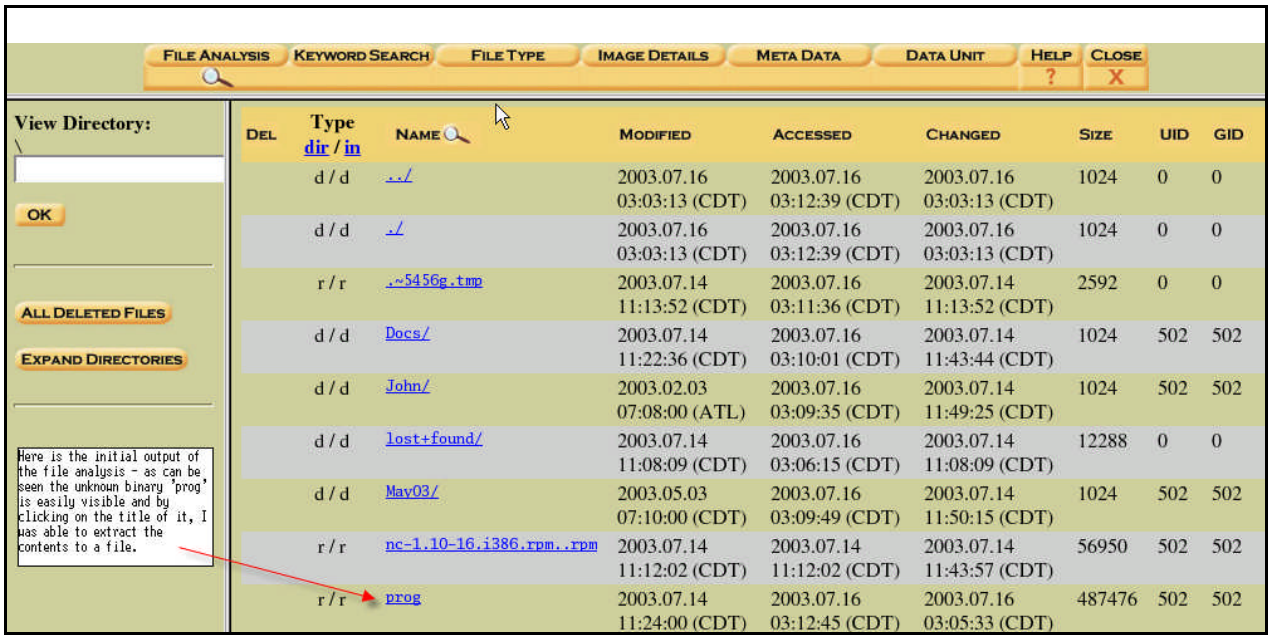
I have compiled the NSRL known MD5hash total databases on my Linux forensic machine. Once in Autopsy I quickly perform a timeline capture (see below) of the image, and then perform a '**file analysis**' search from within the case gallery sub-menu.

Figure 1.14 – Autopsy – File Activity / Time Line Creation Process



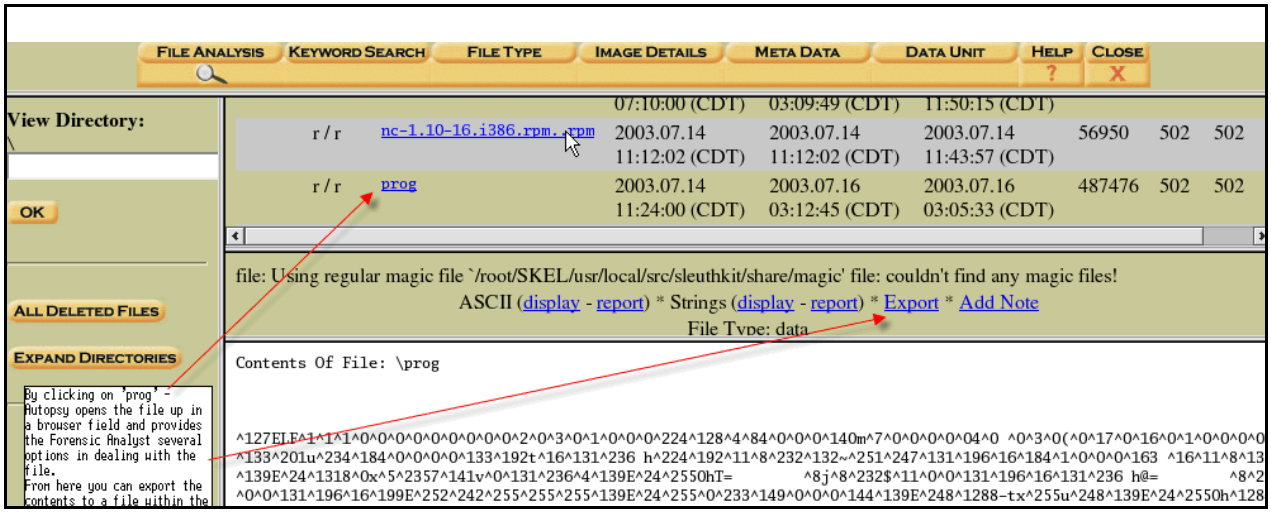
I noted that the image has both allocated and unallocated content which means we will likely have to analyze deleted files during this analysis.

Figure 1.15 Unknown Binary Identification within Autopsy



Using file analysis it is easy to find the '**prog**' file. Once identified it is possible to recover and extract the files using the 'export contents' functionality. Figure 1.16 shows how I identified and exported the unknown binary for further analysis.

Figure 1.16 Unknown Binary Extraction within Autopsy



File MAC/Timeline Analysis:

A timeline provides extremely useful information to a forensic analyst on system modifications, or in re-constructing a chain of events. The process of creating a timeline within Autopsy is rather mundane, in that it is precipitated by clicking an icon and entering in the start date for the timeline and the output file name. You can specify the ending date for a timeline, however you may miss information if the file system dates were altered.

This same process could be done from a command line using the '**grave-robber tool**' from The Coroners Toolkit [4](TCT) assuming that it is installed on the system by using the following command:

grave-robber –E (the –E flag says to grave-robber to grab all file information – however additional flags can be configured - for a complete listing use grave-robber • • help)

Once a timeline has been developed an investigator needs to understand how to interpret the results, particularly the differences between the components of the timeline. The timeline represents three system related events for each individual file, commonly referred to as 'MAC' as outlined below:

Timeline Component	Represents
M – modification time	The last time that a file was written
A – access time	The last time a file was read
C – change time	The last time the inode contents were written.

Using Autopsy I extracted the timeline analysis for this image, and noted that the first entry was January 28,2003 which appears to be the creation and access of two of the three images retrieved. Looking for more information about the timelines for the unknown binary, I extracted only the entries related to 'prog':

```
Mon Jul 14 2003 11:24:00   487476 m.. -/-rwxr-xr-x 502     502     18
\/prog

Wed Jul 16 2003 03:05:33   487476 ..c -/-rwxr-xr-x 502     502     18
\/prog

Wed Jul 16 2003 03:12:45   487476 .a. -/-rwxr-xr-x 502     502     18
```

[4] Coroners Toolkit (TCT) can be located http://www.porcupine.org/forensics/tct.html

```
\/prog
```

We can see that the unknown binary was brought onto the machine **July 14th at 11:24**, is **487476** bytes in size and has both a user and group ownership value of 502 (unfortunately we do not have a copy of the /etc/group file to further analyze the memberships of this group (but it is likely all users), in any event the file is set to '**rwxr-xr-x**' meaning that the owning UID/GID have read, write and execute permissions on this file, while all system users have the ability to read and execute this file but not necessarily write to the file. It is interesting to note that the last time the program was accessed was **July 16, 2003 at 3:12 AM,** the same day that the image was taken (which we can assert was the day the evidence was seized).

So far the analysis has shown several references to **nc-1.10-16..i386.rpm** and within the timelines we see specific entries about this nc rpm including the original creation and access date and time of July 14, 2003 at 11:12 AM and a change entry on the same date but at 11:43 AM.

```
\/nc-1.10-16.i386.rpm..rpm
Mon Jul 14 2003 11:12:15   100430 ma. -rwxr-xr-x 0       0       23
<fl-160703-jp1.dd-dead-23>
```

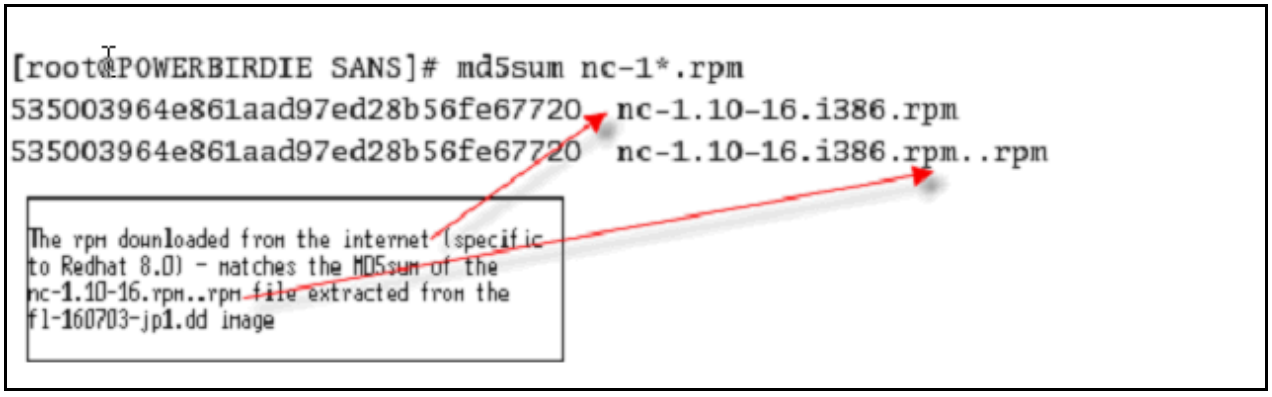
We are able to see that Netcat initially appears in this timeline on July 14, 2003 at 11:12 AM. This is likely the compile date and time of Netcat.

```
Mon Jul 14 2003 11:43:57    56950 ..c -/-rwxr-xr-x 502     502     22
\/nc-1.10-16.i386.rpm..rpm
```

Netcat Reference Explored:

Using Autopsy I was able to extract the nc-1.10-16.i386 rpm binary, and upon analysis determine that the file extracted from the image was the actual rpm that one would use to install 'netcat' on a system. Using a Google search with criteria of **'nc-1.10-16.i386.rpm'** I found that this specific rpm is the Redhat 8.0 rpm for nc. I found and downloaded a copy of the rpm from the website (http://rpmfind.rediris.es/rpm2html/redhat-8.0-i386/nc-1.10-16.i386.html) and performed an MD5Sum on it and the one extracted from the fl-160703-jp1.dd image from SANS. The MD5Sum hash totals matched, and so I now know that the system that John Price was likely using was using Redhat 8.0 as it's base operating system, or that he had some dual boot, or VM configuration of Redhat 8.0. Additionally we know have evidence that Netcat was present on his machine.

Figure 1.17 MD5 Comparison of NetCat Binary found and downloaded

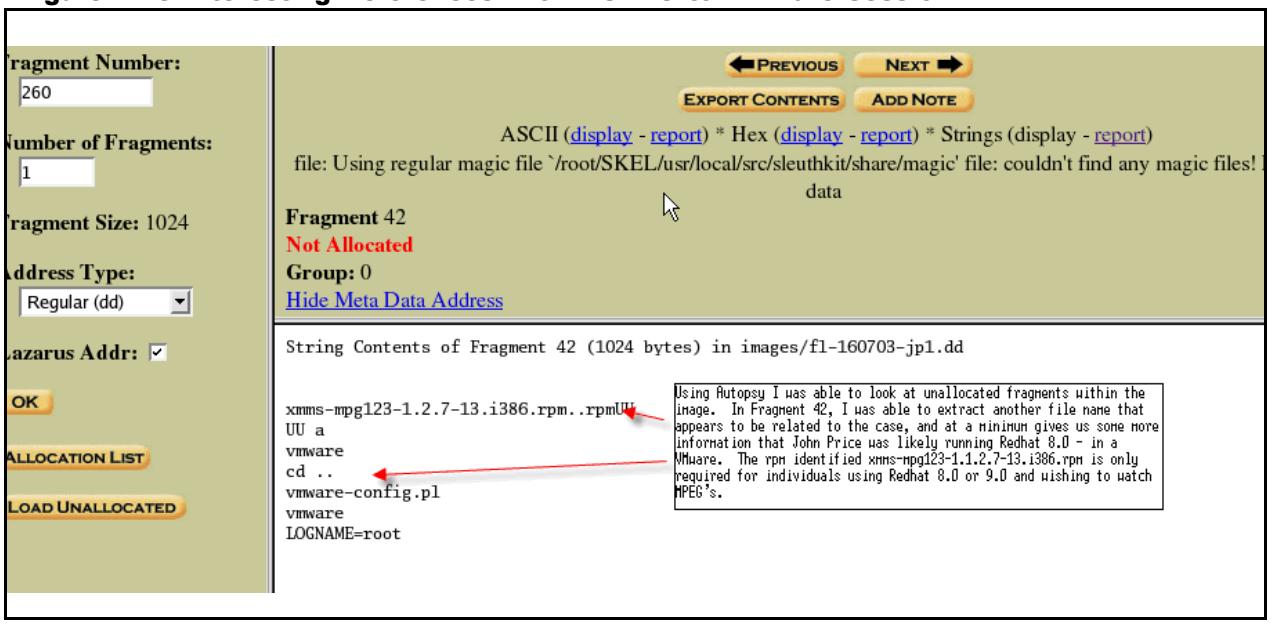


Netcat (nc) is defined on the same rpm website as 'a simple utility for reading and writing data across network connections, using the TCP or UDP protocols. Netcat is intended to be a reliable back-end tool which can be used directly or easily driven by other programs and scripts. Netcat is also a feature-rich network debugging and exploration tool, since it can create many different connections and has many built-in capabilities'. From experience I know that 'nc' can be used to copy files to / from remote computers, execute commands remotely etc. This leads me to believe that John is likely using

'nc' in connection with his illegal activities and most likely to connect remotely to another machine to retrieve the copyrighted material.

Given that the rpm found was for Redhat 8.0, and the workstation appeared to be a Microsoft based on the presence and use of Microsoft Word 8.0, it is likely that this version of Netcat was either run from a dual boot machine or within a virtual machine. With further investigation of the full image I was able to extract evidence that Netcat was likely run in a virtual machine using Vmware (www.vmware.com).

Figure 1.18 Interesting References within SANS to Vmware session.



Within Autopsy I identified a fragmented inode on the image that contained remnants of references to vmware.

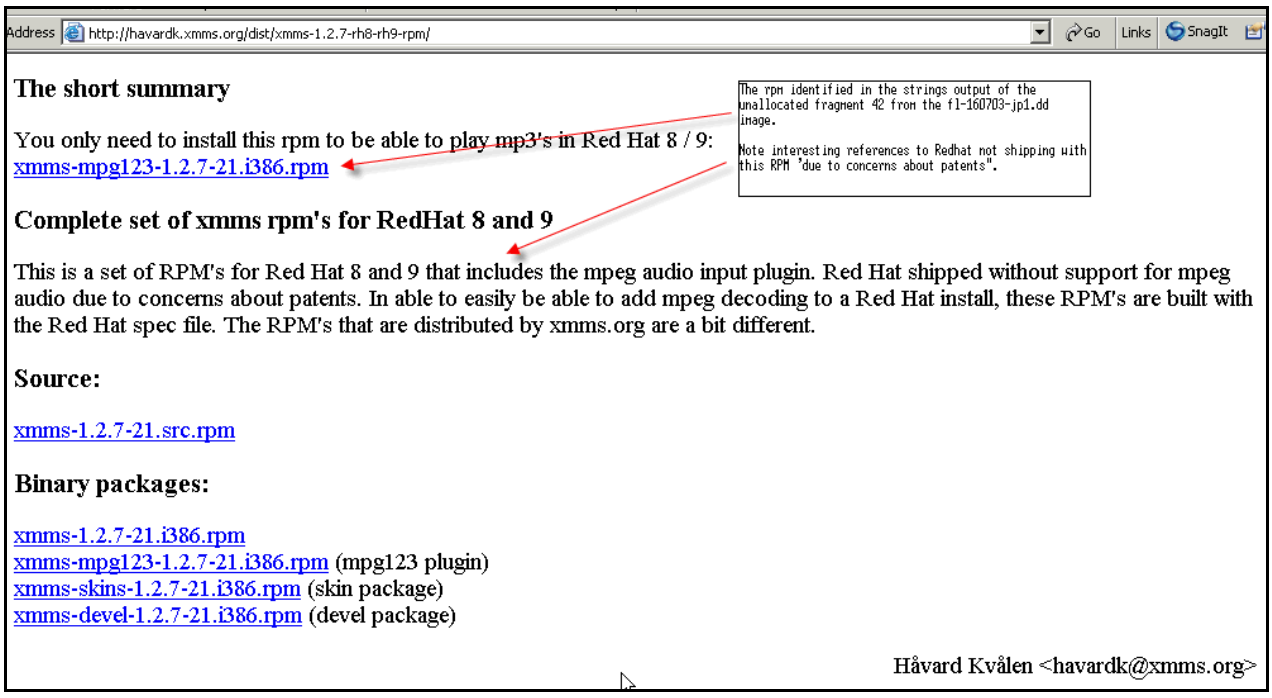
An extract of fragment #42 found using Autopsy

```
        Autopsy string Fragment Report (ver 1.74)

---------------------------------------------------------------
Fragment: 42
Length: 1024 bytes
Invalid address in indirect list (too large): 134996352Not allocated to
any meta data structures
MD5 of raw Fragment: e1067497002867b59c8e1953da221c25
MD5 of string output: 5a18a616b1dbb5016819365948c6ac44
Image: /forensics//SANS-Unkown_Binary/SANS-ASSIGN1/images/fl-160703-
jp1.dd
Image Type: linux-ext2
Date Generated: Mon Jan 05 02:05:59 2004
Investigator: unknown
---------------------------------------------------------------
xmms-mpg123-1.2.7-13.i386.rpm..rpmUU
UU a
vmware
cd ..
vmware-config.pl
vmware
LOGNAME=root
```

To ensure that the analysis was complete a Google search with the following search criteria **'xmms-mpg123-1.2.7.13-i386.rpm'** confirmed my expectations that this was a Linux source code package. It appears that this

specific rpm is needed by Redhat 8.0 or 9.0 to handle mpeg audio input[5]– which seems to follow the possible scenario that we are investigating. It also gives further support that we are looking at either a dual boot machine or a machine with VMware installed.

Figure 1.19 Unknown RPM References Explored in Google Search

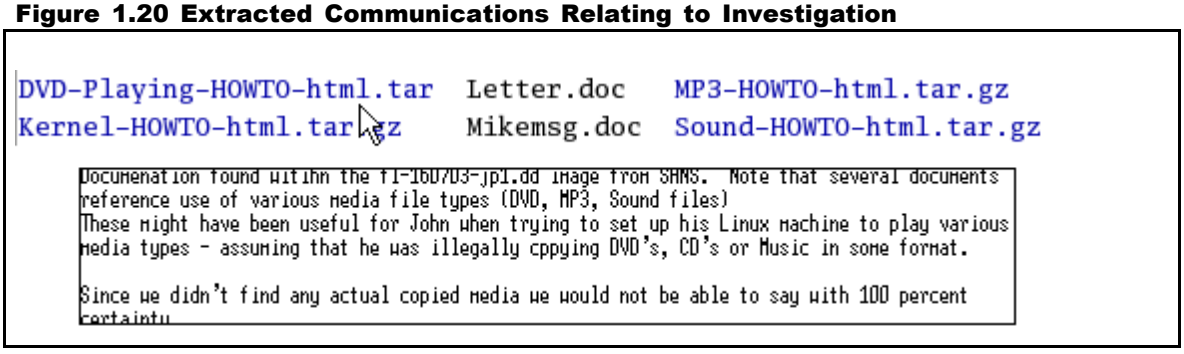


In addition to extractable files and various references to rpms', from the image I was able to extract some correspondence between John Price and an individual called Mike.

Correspondence Found:

Figure 1.20 illustrates two Microsoft word documents and several pieces of documentation. Through Autopsy I extracted each of these for further analysis.

Figure 1.20 Extracted Communications Relating to Investigation



One word document details a communication between John Price and an individual referred to as 'Mike' (located in a file called Mikemsg.doc, which appears to have been created on July 14th, or 2 days before the image was created (so close to the investigation initiation).

'Hey Mike,
I received the latest batch of files last night and I'm ready to rock-n-roll (ha-ha).

[5] Taken from http://havardk.xmms.org/dist/xmms-1.2.7-rh8-rh9-rpm/

I have some advance orders for the next run. Call me soon.
JP'

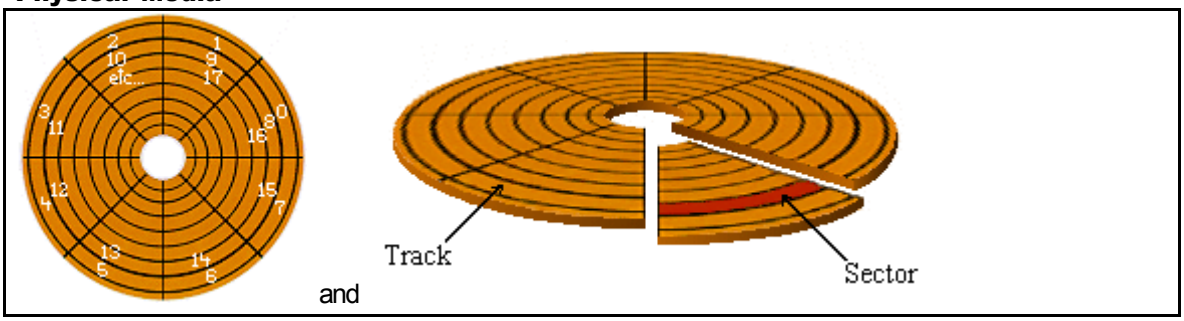
This communication is interesting as it indicates that John Price received 'the latest' indicating that there has been past batches of copyrighted material illegally copied and gives a sense that he is not acting alone. Additionally he appears to have a pre-defined market for his stolen goods and is willing to source items that they would like. This would typically indicate that he trusts these individuals (both to buy illegal copies, and to formalize the process enough to start taking requests).

The other items of note was the reference to 'last night' and 'next run', this might give us a sense that the individual is using the IT resources overnight, or is collecting the files at night and processing them during normal business hours. Additionally when I read 'next run' I envision a process which is actually re-copying material into a more useable format (i.e. copying CD's). Finally it is signed by 'JP', which I have taken to be John Price our suspect. This links his activities to him.

Graphic Images Found:

During our analysis I was also able to identify three (3) pictures located within the fl-160703-jp1.dd image. Two of the images sect-num.gif, and sector.gif respectively – seem to depict a hard-disk and the allocations of physical media sectors.

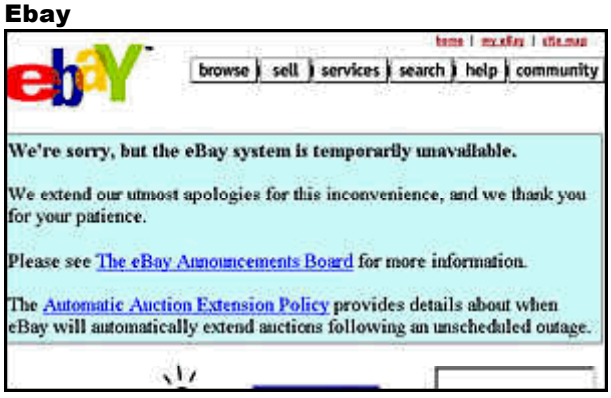
Figure 1.21 Graphic Images retrieved from SANS Unknown Binary Assignment – Physical Media



Since the scenario provided by SANS indicates that John Price was using the company's IT resources to illegally distribute copyrighted material, this might indicate that John had to do some research on how to make an exact copy (and hence the reason behind track and sectors).

Figure 1.22 depicts the final image ebay300.gif which appears to be un-related to this investigation – although at first I thought it might be a means for John Price to sell the copyrighted materials. I did not investigate this further at this point in time.

Figure 1.22 Graphic Image retrieved from SANS Unknown Binary Assignment - Ebay



So far our analysis tends to lead us to John Price copying some form of entertainment (Music, Video, DVD) using an unknown program. Given the nature of the items he is likely copying, my expectation is that the unknown binary will be a 'ripper' or image utility of some type to make illegal copies of DVD's, CD's or other media. Such a utility would be used to possibly break the encryption around a movie for instance and then allow the person to make illegal copies of the same CD or DVD. Let's move to the binary analysis now.

Binary Analysis:

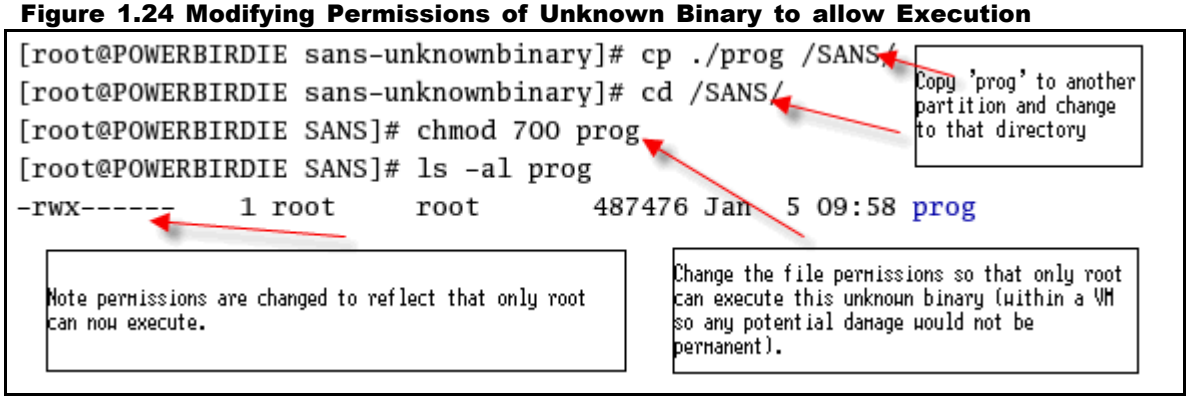
Having identified the file called '***prog***' as the unknown binary from SANS and verifying its integrity I started by using the **'ls –l prog'** command to show the file permissions for prog.

Figure 1.23 Identified Binary File Permissions

```
[root@POWERBIRDIE sans-unknownbinary]# ls -l prog
-rwxr-xr-x    1 JLO      JLO        487476 Jul 14 11:24 prog
```

Note that JLO is one of the UIDs on my forensic machine and so the name is not that of the original machine, rather it has inherited the user and group references that are on this particular machine. What is interesting is that the permissions is executable by all individuals on the system. This would of course assume that we hadn't set the mount options to 'read only' and 'noexec'. As it is currently mounted we will not be able to execute the binary for our investigation. So I will first copy 'prog' to a partition that will allow me to execute the binary when necessary. I will at the same time change the permissions to ensure that it isn't accidentally executed by another system user (which is unlikely as it is an air-gapped laptop). To do this we use 'chmod 700 prog' and perform another **'ls –al prog'**

Figure 1.24 Modifying Permissions of Unknown Binary to allow Execution



Comfortable that only root can execute this binary, it is important to extract as much information without actually executing it. To extract some basic information about the binary I will use the 'file' utility in Linux to extract any useful information.

Figure 1.25 File Utility Output Against Unknown Binary

```
[root@POWERBIRDIE SANS]# file prog
prog: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), statically linked, stripped
```

As Figure 1.25 shows, the binary is a Linux executable that is statically linked and is considered version 1. This leads me to believe that it is not dependant on the existence of any shared libraries. I will confirm this with the 'ldd' utility that will identify any interesting shared libraries that might be needed to execute the binary.

Figure 1.26 Identification of Linked Libraries

```
[root@POWERBIRDIE SANS]# ldd prog
        not a dynamic executable
```

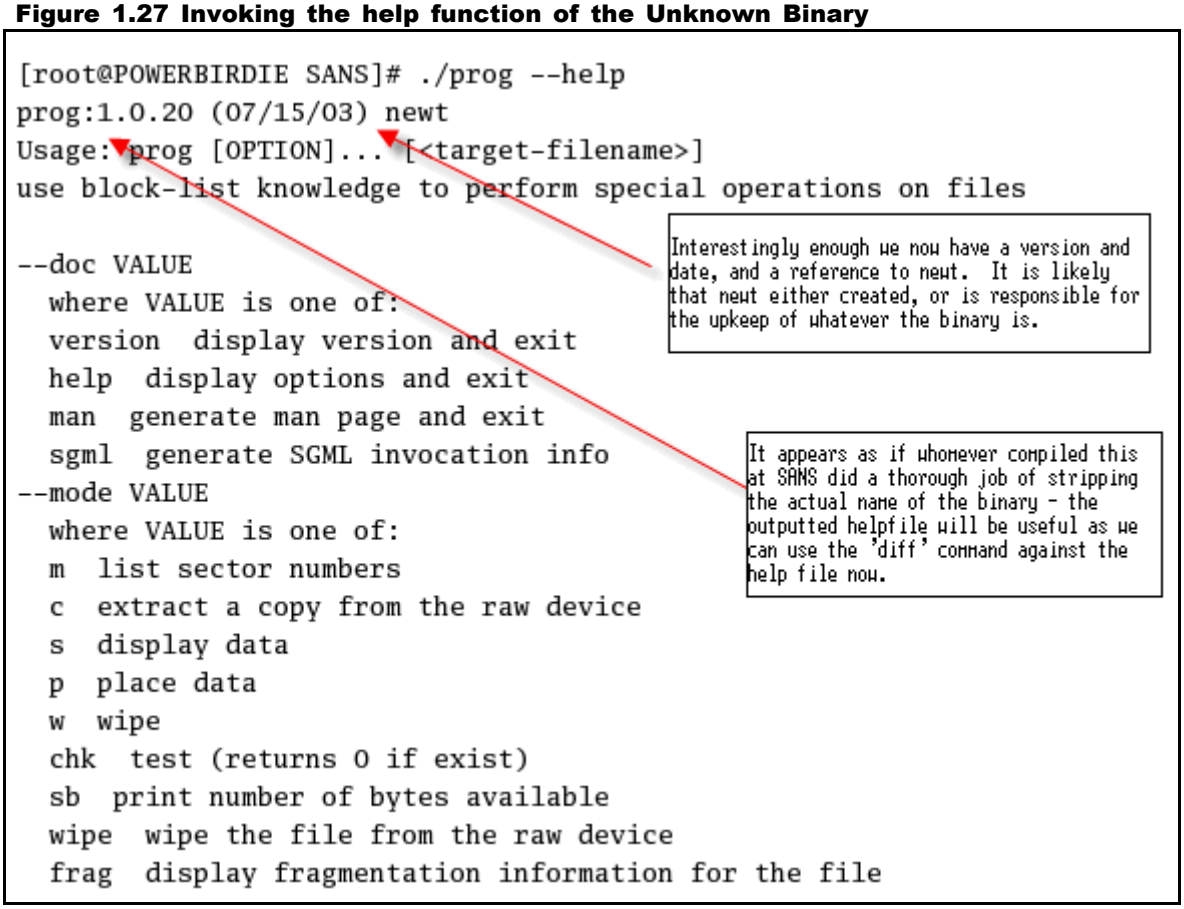
So we are not looking for a binary that requires shared libraries to function properly, this might mean that the program could be run as a stand-alone or run from a CD or floppy. As a next step I will see if any help files exist.

Helping Myself to Help:

In an attempt to see the usage pattern of this unknown binary I decided to try to see if there was a help file associated with it. This test is rather harmless as it doesn't actually execute the binary – only shows you the help file.

To test for this I used **'./prog • • help',** which invokes a help file if available. The output was interesting, and so I re-ran the same command but added an optional output redirection flag so that I could review the help file in a text editor, or possibly use it for comparative purposes.

Figure 1.27 Invoking the help function of the Unknown Binary



The rest of the help file makes references to various configuration specific help. I decided that since some of the relevant information was obfuscated, that I might yield better results from the use of the strings utility that reads the contents of a file and shows any printable characters.

Strings Search:

Often extremely useful information is contained within the source code of the binaries / programs themselves. It might be for de-bugging purposes, programmer documentation or simply a wise-guy programmer wanting to take some personal credit. In any event it is also very useful in most cases to help identify unknown

binaries. Next I run 'strings' against prog and output it to a file. The output was eighty-nine (89) pages in length, so I have extracted the parts that I used from this output and incorporated them into this document. For a full listing of the output file see **Appendix A**.

`'1.0.20 (07/15/03)'` – appeared to be a version and date reference for this file – so potentially useful for comparative purposes later on.

`'newt'` – appears to be a specific references to an individual who was also referenced in the help files – possibly an Internet 'handle' for whomever is taking care of bug fixes or at least tracking them.

`'use block-list knowledge to perform special operations on files'` – appeared to be some specific help related information for 'prog'

Use of BinText:

Since the strings output wasn't the easiest to use and didn't provide me with many valuable pieces of information I decided to use **BinText**[6] to load the 'prog' file and extract the following text which appeared to be part of a help file. Specifically I was interested in the following:

'0004C880 0004C880 0 use block-list knowledge to perform special operations on files'

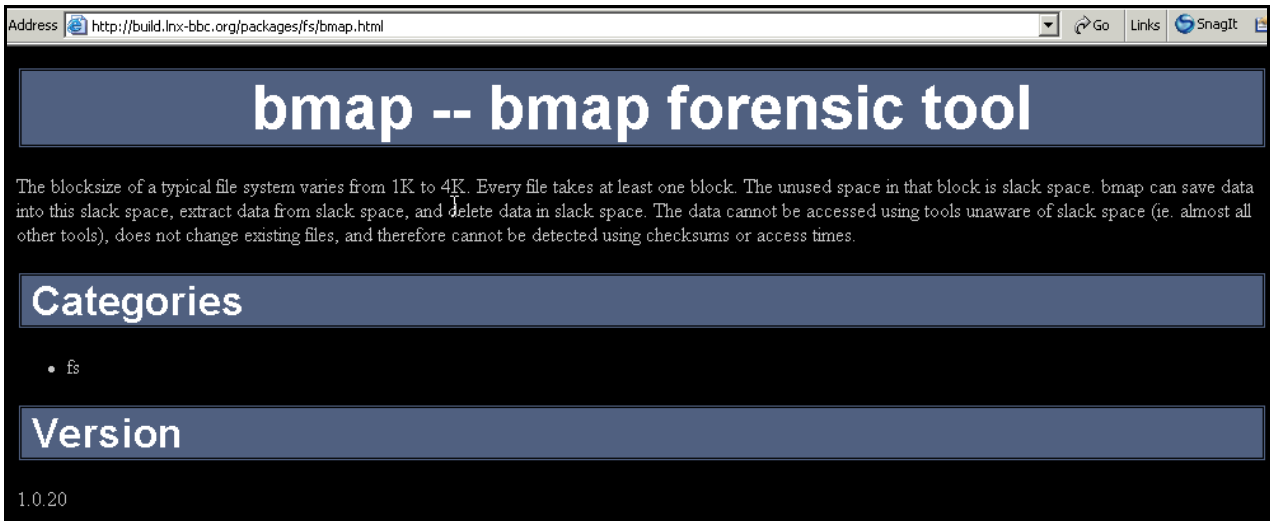
This appeared to be some binary specific type information, which I confirmed by moving to the networked machine and performing a Google[7] search on the following:

'use block-list knowledge to perform special operations on files'

One of the Google search pages returned was http://lwn.net/2000/0420/announce.php3 and referenced a product called bmap v1.0.17. Interested in this I decided to see first if there was a version 1.0.20 (using Google with a search criteria of '**bmap 1.0.20**') – which in fact there was. I downloaded it from another website (http://build.lnx-bbc.org/packages/fs/bmap.html)

Figure 1.28 depicts a likely match to the unknown binary.

Figure 1.28 Identification of Unknown Binary Website Reference



[6] BinText is a text extractor freeware tool that can be located at www.foundstone.com/resources/proddesc/**bintext**.htm .

[7] www.google.ca (Canadian version) www.google.com (U.S. version) www.foundstone.com/resources/proddesc/**bintext**.htm

It is interesting that the references and analysis now appears to point to a forensic imaging tool not a ripper program. This would makes sense as John would want to make exact copies of media, then he would be using an imaging tool that is capable of performing 'true' copies, which typically requires bit-stream-copies[8].

BMAP Version 1.0.20

To determine if BMAP was in fact the unknown binary, I felt it prudent to download the source from this website, and then perform some analysis on it. The first step was to obtain the source file and un-gzip and un-tar it, in essence I uncompressed the source files and loaded them to my Unix based analysis machine (once downloaded from my networked machine with Internet connectivity).

MD5Sum hash total:

Ideally we would be able to compare the outputs of the MD5Sum hash totals for each file and have a perfect match. Unfortunately this is not typically the way that things work in a forensic investigation and when I tried to compare the MD5Sum hashes of these two files, they were different. This indicates that the content of each file has at least a single character difference.

Figure 1.29 Bmap and Unknown Binary MD5Sum Comparisons.

```
[root@POWERBIRDIE bmap-1.0.20]# md5sum prog bmap
7b80d9aff486c6aa6aa3efa63cc56880  prog
ea6b4ce0c141263dfe9edf75d79b218a  bmap
```

This makes sense as we will see later from the footprint of bmap that it writes specific lines into the files about the compile date, which would result in different MD5's. Additionally any variants in the system configuration, such as the error below that I received during compilation would result in slight variances in the way that bmap was compiled on my system, even if it works fine against our test files.

"make: sgml2latex: Command not found
make: *** [doc] Error 127"

Libraries Required:

Having identified that the MD5's do not match, I decided to see which libraries bmap uses and see if I can find evidence of the same dependencies for the unknown binary. To do this I used the 'ldd' utility against the bmap executable and identified that it calls **libs.so.6** and **ld-linux.so.2** as illustrated in Figure 1.30 below.

Figure 1.30 Identification of Bmap Required Libraries

```
[root@POWERBIRDIE bmap-1.0.20]# ldd ./bmap
        libc.so.6 => /lib/i686/libc.so.6 (0x42000000)
        /lib/ld-linux.so.2 => /lib/ld-linux.so.2 (0x40000000)
```

The same command against the unknown binary did not result in similar results, as the unknown binary did not have the dependencies available. From the image however, I was able to use Autopsy to extract references for the same libraries using a keyword search on **libc**. . While this isn't conclusive evidence on it's own it does lead us to further believe that the unknown binary is bmap. Next I wanted to look for any type of unique characteristics that the software might leave during a compile.

Figure 1.31 Autopsy Existence of Bmap Required Libraries

[8] Bit-Stream refers to a process where the image is made by copying over the ones and zeros of a file one bit at a time – resulting in a true likeness to the original. This is similar to forensic image using the 'dd' utility.

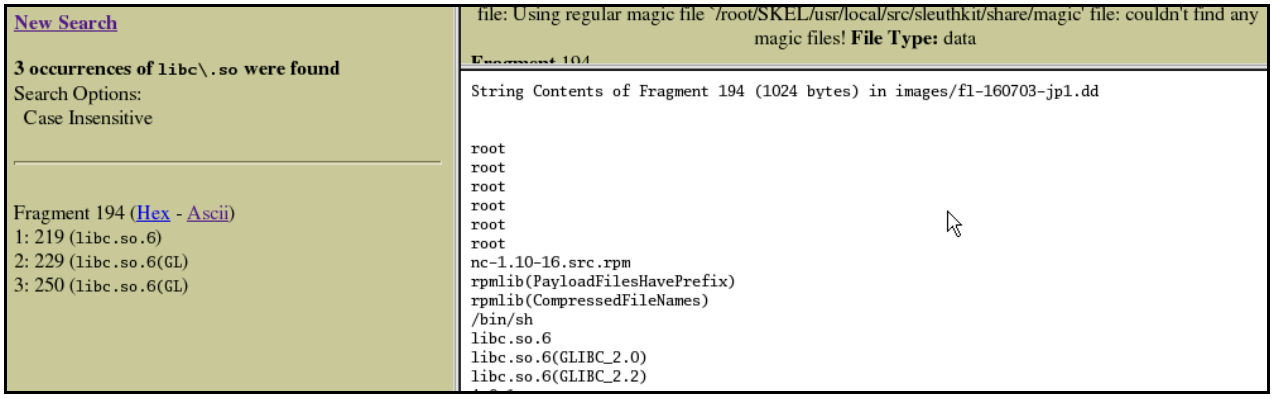
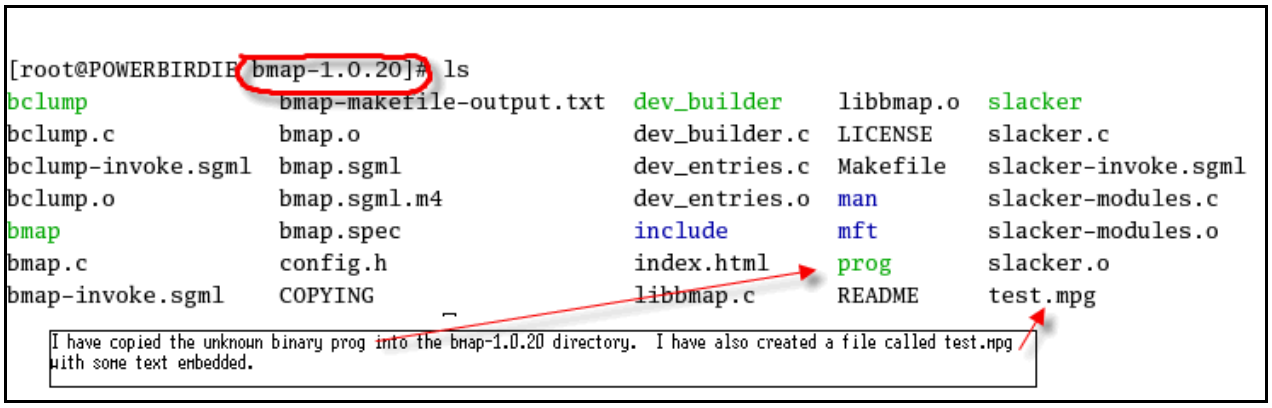
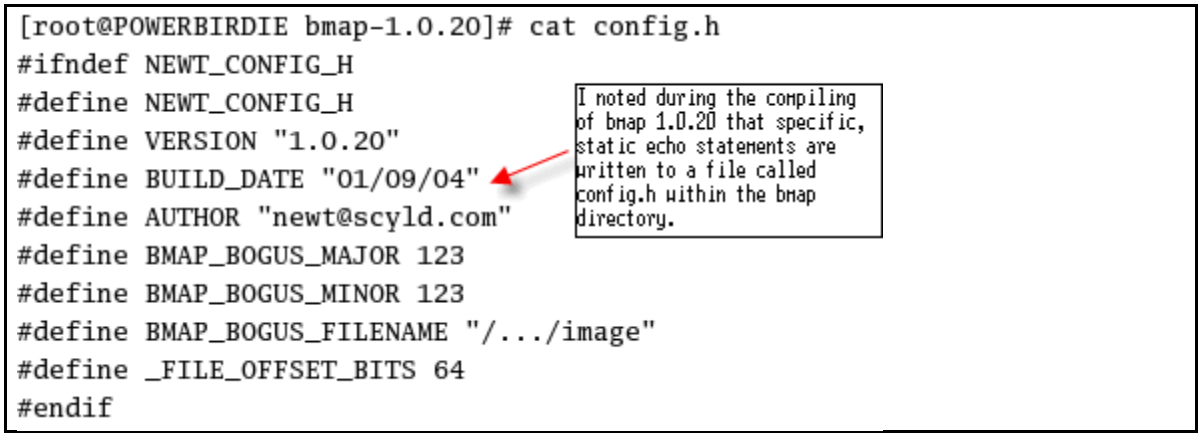


Figure 1.31 Compilation of Bmap and Files Created



Footprint Analysis:

Each piece of software leaves a unique footprint as it is compiled and/or executed on a system. For instance bmap has a unique way of defining echo statements into files as it is compiling. As an example a file within the bmap directory called config.h contains the compile date, 01/09/04, which is the system date on my machine during compilation. We see other examples in the help files and others.

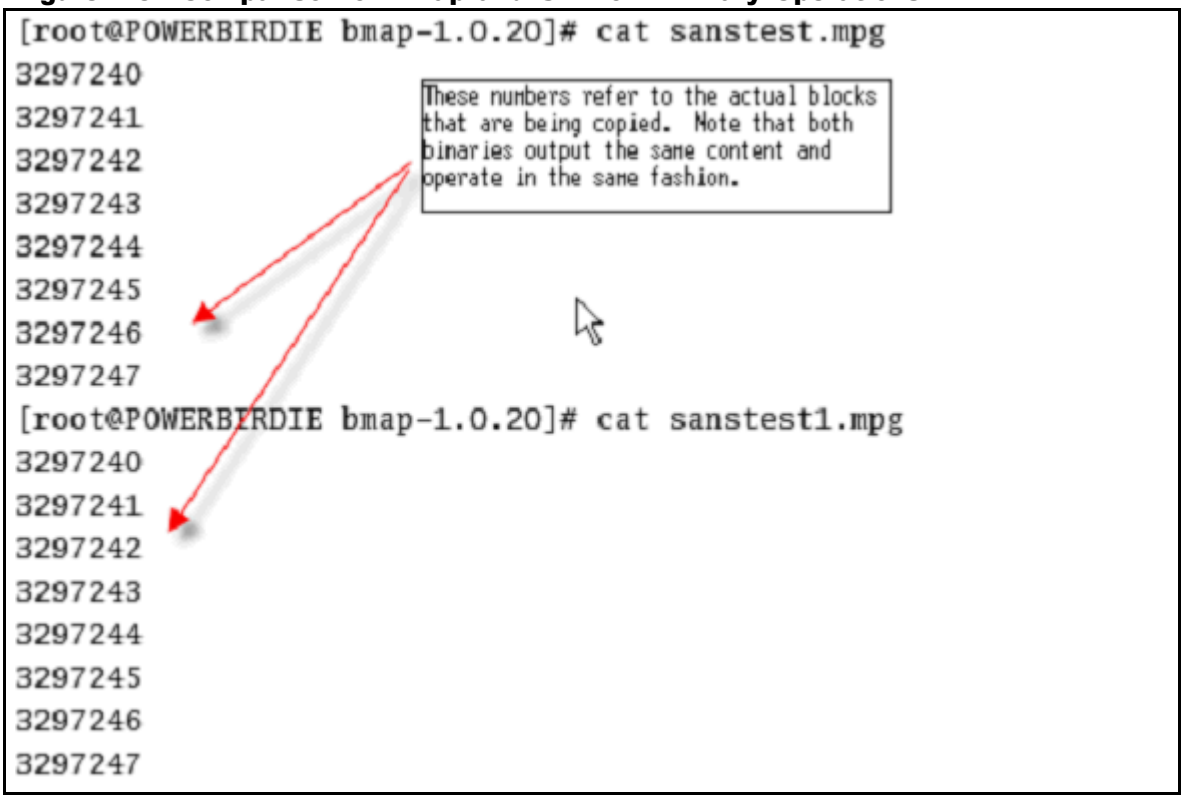


Knowing that these unique characteristics exist, an investigator or even an administrator could now target a system and create a simple shell script that would look for a combination of a **config.h** files with the term '**newt@scyld.com**'. Additionally they could look for the mere presence of **newt_conf_h** files on their system.

Do the individual binaries outputs compare?:

One way to be able to prove that the unknown binary is actually bmap v1.0.20 is to see if the two files operate in the same fashion on the same test file. To do this I have compiled bmap 1.0.20 into a VM session, and also copied the unknown binary to the same directory. Additionally I created a file called test.mpg to use in the analysis of both files.

Figure 1.32 Comparison of Bmap and Unknown Binary Operations

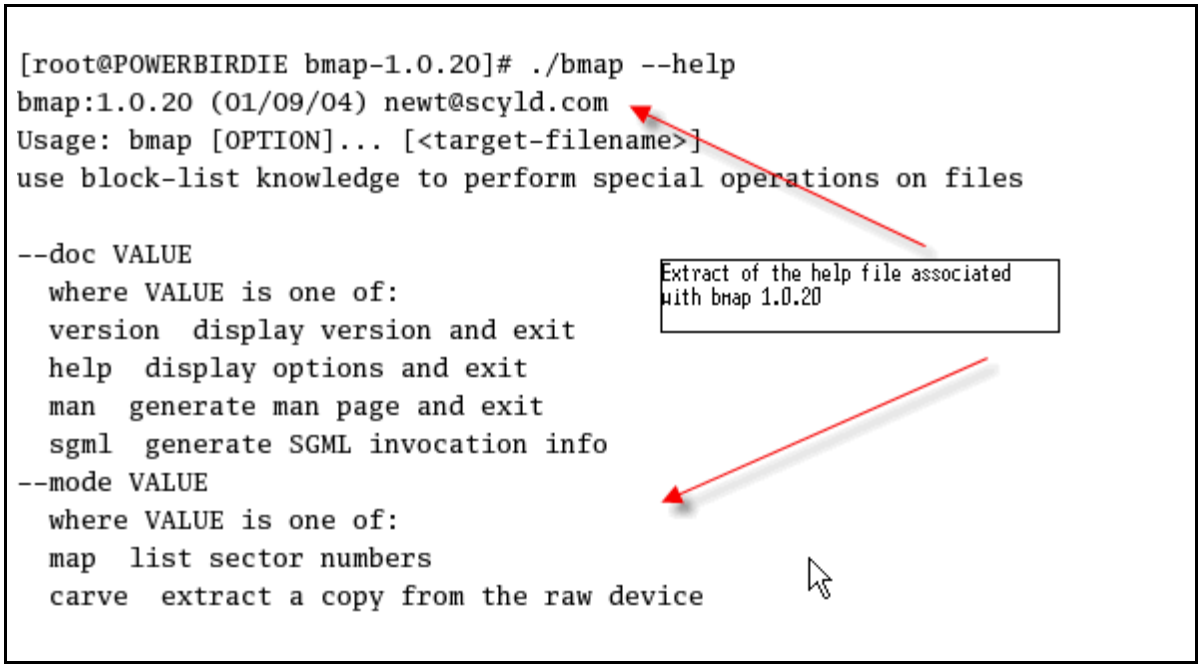


As we can see the two binaries handle the test.mpg file in exactly the same way, and appear to be performing a bit-stream level copying of the files. The files only contain one line of text so the output appears to be an appropriate amount.

Comparison of Help Files

Finally, as a last step before concluding that the unknown binary is bmap 1.0.20 I decided to compare the outputs of the help files that are associated with each. Figure 1.34 shows us the help file from bmap 1.0.20:

Figure 1.34 Extract of Bmap Help File



Now we examine the help file associated with 'prog' (the unknown binary) as illustrated in Figure 1.35 below.

Figure 1.35 Extract of Unknown Binary Help File

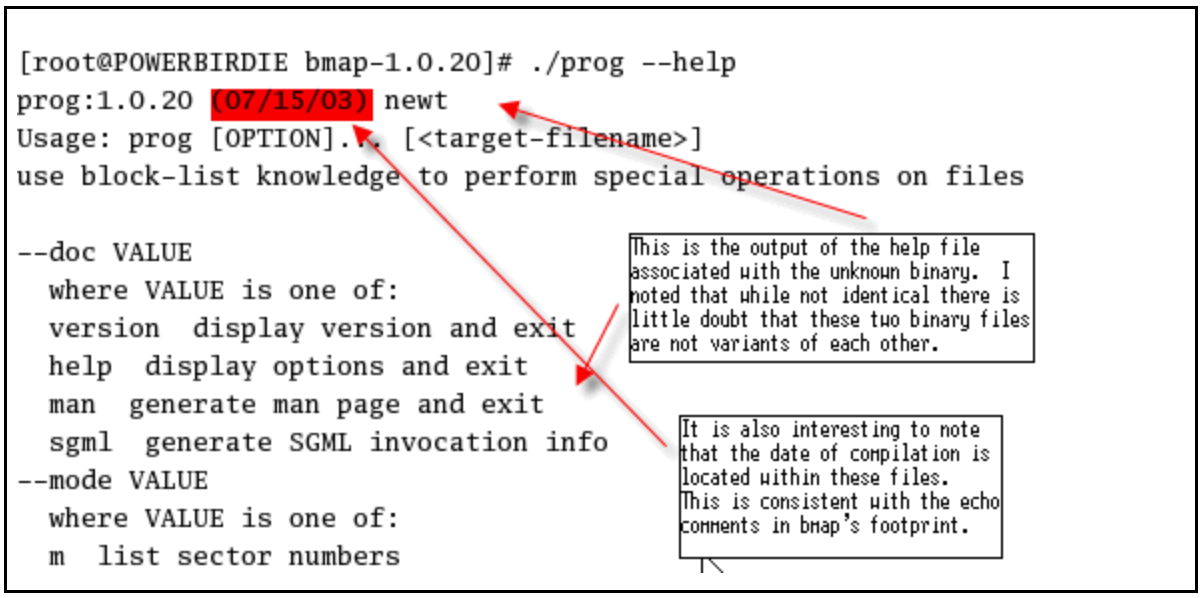
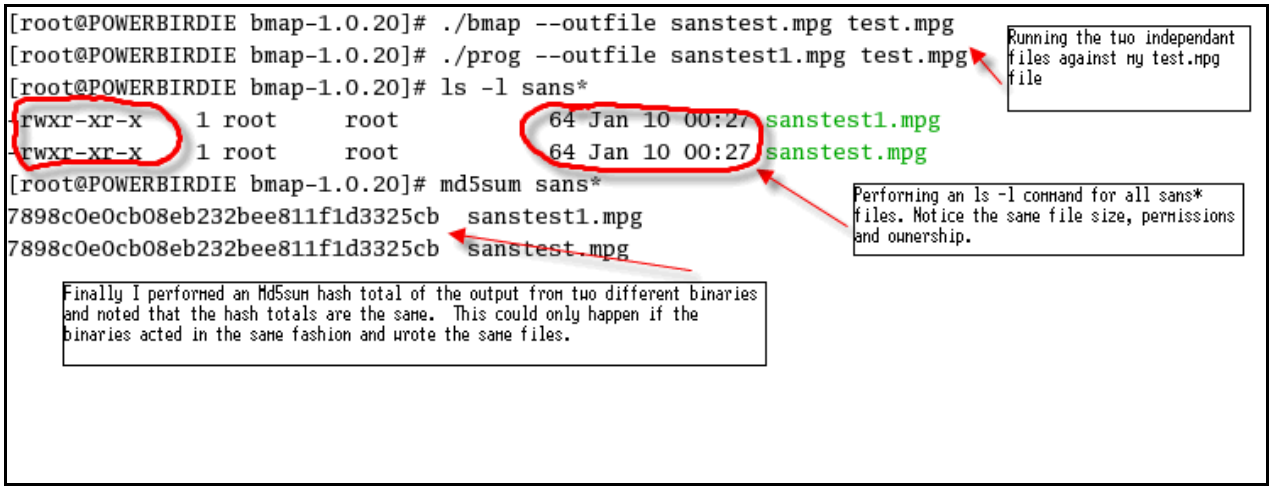


Figure 1.36 Comparison of the Functions of Each Binary



All the above analysis leads me to believe that the unknown binary is bmap v1.0.20.

STRACE Comparison:

Another good approach to seeing how a binary interacts with a system is to use the debugging tool 'strace', which traces the interactions the binary performs on a system. While I do not expect that the output would be the same, as an investigator it would provide some additional assurance if there were similar characteristics in each file. We start off with the **strace** output for the unknown binary, as it is likely going to have fewer interactions on the system as it was not compiled on it.

```
[root@POWERBIRDIE bmap-1.0.20]# strace ./prog
execve("./prog", ["./prog"], [/* 32 vars */]) = 0
fcntl64(0, F_GETFD)                     = 0
fcntl64(1, F_GETFD)                     = 0
fcntl64(2, F_GETFD)                     = 0
uname({sys="Linux", node="POWERBIRDIE", ...}) = 0
geteuid32()                             = 0
getuid32()                              = 0
getegid32()                             = 0
getgid32()                              = 0
brk(0)                                  = 0x80bedec
brk(0x80bee0c)                          = 0x80bee0c
brk(0x80bf000)                          = 0x80bf000
brk(0x80c0000)                          = 0x80c0000
write(2, "no filename. try \'--help\' for he"..., 36no filename. try '--help' for help.
) = 36
_exit(2)                                = ?
```

I then ran the same utility on the bmap binary, and note that there is several similarities, and while not conclusive – once again a good indication that we have identified the unknown binary as bmap.

Figure 1.33 Strace Utility of Bmap

```
[root@POWERBIRDIE bmap-1.0.20]# strace ./bmap
execve("./bmap", ["./bmap"], [/* 32 vars */]) = 0
uname({sys="Linux", node="POWERBIRDIE", ...}) = 0
brk(0)                                  = 0x806df20
open("/etc/ld.so.preload", O_RDONLY)    = -1 ENOENT (No such file or directory)
open("/etc/ld.so.cache", O_RDONLY)      = 3
fstat64(3, {st_mode=S_IFREG|0644, st_size=61962, ...}) = 0
old_mmap(NULL, 61962, PROT_READ, MAP_PRIVATE, 3, 0) = 0x40013000
close(3)                                = 0
open("/lib/i686/libc.so.6", O_RDONLY)   = 3
read(3, "\177ELF\1\1\1\0\0\0\0\0\0\0\0\0\3\0\3\0\1\0\0\0\220Y\1"..., 1024) = 1024
fstat64(3, {st_mode=S_IFREG|0755, st_size=1395734, ...}) = 0
old_mmap(0x42000000, 1239844, PROT_READ|PROT_EXEC, MAP_PRIVATE, 3, 0) = 0x42000000
mprotect(0x42126000, 35620, PROT_NONE)  = 0
old_mmap(0x42126000, 20480, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED, 3, 0x126000) = 0x4212
0
old_mmap(0x4212b000, 15140, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0)
x4212b000
close(3)                                = 0
old_mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x40023000
munmap(0x40013000, 61962)               = 0
write(2, "no filename. try \'--help\' for he"..., 36no filename. try '--help' for help.
) = 36
 exit(2)                                = ?
```

Unknown Binary Program Identification:

Based on the above analysis the unknown binary is called **bmap v1.0.20**, and is **487 476** bytes in size.

Having identified the binary as BMAPV1.0.20, at this point I would likely confront John Price with our forensic analysis to try and pose the following questions that might help further understand the full spectrum of evidence.

Potential Questions:

If I were able to sit down with John Price and was given the chance to ask five questions I would likely use the following questions which I feel will be helpful in the investigation but not come across as a direct attack on him.

1.) 'John, during the investigation I have identified several programs (binaries) that are not standard programs for our deployments. Given that this was your machine did you happen to load any non-standard programs on your machine? If you did we would like to know what they were so that we can identify if you possibly installed a 'trojan'd' version of a file? It might be possible that you could have inadvertently loaded files without knowing it?' [it is important to always allow them the possibility of helping themselves]

2.) 'John, from what I was able to analyze it appears that somehow the company's IT resources were being used for non-business purposes during non-business hours Do you think that this is a serious issue?' [this will give an investigator a sense of the moral fiber of the individual that they are investigating, in practice similar questions have been enough for an individual to state that they were wrong to do this type of thing but didn't understand the gravity of their actions]

3.) 'John, the evidence seems to lead me to believe that you and other individuals were using the company's computers and network resources inappropriately, apparently to try and break copyright laws. Management is taking this very seriously and wants to ensure that this does not happen again. Is there anyone else that was involved?

4.) 'John is it possible that I am not getting the full picture based on the evidence that I am seeing, or that it seems worse than it really was? Did you care to help clarify your actions? – I would really like to clear this up before it gets out of

hand' [this gives them the sense that you have found evidence of wrong doing and might infer the worst possible solution – it might be enough for them to want to try and clear their name / of confess to their actions]

5.) ' John, I have to admit that based on the evidence that we were able to collect, and the fact that you attempted to wipe some evidence from the system prior to your departure does nott look good for you. Why did you try to wipe information from your computer? What were you afraid we would find? [sometimes you have to play it hard with these individuals, and often their reasoning for destroying evidence is not what we think they did it for.]

Appendix A: Strings output for unknown binary ‘prog’

This a embedded PDF document that contains the full content of the strings output against the ‘prog’ file. I choose to embed the document as a PDF because the full file was approximately eighty plus (80+) pages.

"Output of command strings prog.pdf"

Appendix B: Forensic Footprint of Bmap v1.0.20

This is the output of the 'make' command for bmap 1.0.20.

```
echo "#ifndef NEWT_CONFIG_H" > config.h
echo "#define NEWT_CONFIG_H" >> config.h
echo "#define VERSION \"1.0.20\"" >> config.h
echo "#define BUILD_DATE \"01/09/04\"" >> config.h
echo "#define AUTHOR \""newt@scyld.com"\"" >> config.h
echo "#define BMAP_BOGUS_MAJOR 123" >> config.h
echo "#define BMAP_BOGUS_MINOR 123" >> config.h
echo "#define BMAP_BOGUS_FILENAME \""/.../image"\"" >> config.h
echo "#define _FILE_OFFSET_BITS 64" >> config.h
echo "#endif" >>config.h
if [ -n mft ] ; then make -C mft ; fi
make[1]: Entering directory `/UNKNOWN_Binary/bmap-1.0.20/mft'
echo "#define MFT_VERSION \"0.9.2\"" > mft_config.h
echo "#define MFT_BUILD_DATE \"01/09/04\"" >> mft_config.h
echo "#define MFT_AUTHOR \""newt@scyld.com"\"" >> mft_config.h
cc -Wall -g -I. -Iinclude  -c -o option.o option.c
cc -Wall -g -I. -Iinclude  -c -o log.o log.c
log.c:354: warning: `syslog_dispatch' defined but not used
log.c:361: warning: `html_dispatch' defined but not used
cc -Wall -g -I. -Iinclude  -c -o helper.o helper.c
ld -r --whole-archive -o libmft.a option.o log.o helper.o
make[1]: Leaving directory `/UNKNOWN_Binary/bmap-1.0.20/mft'
cc -Wall -g -Imft/include -Iinclude -Lmft -lmft  dev_builder.c  -o
dev_builder
mft/libmft.a: In function `mft_log_perror':
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:297: `sys_errlist' is deprecated; use
`str
error' or `strerror_r' instead
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:294: `sys_nerr' is deprecated; use
`strerr
or' or `strerror_r' instead
cc -Wall -g -Imft/include -Iinclude  -c -o bmap.o bmap.c
bmap.c: In function `main':
bmap.c:371: warning: implicit declaration of function `dprintf'
cc -Wall -g -Imft/include -Iinclude  -c -o libbmap.o libbmap.c
./dev_builder > dev_entries.c
cc -Wall -g -Imft/include -Iinclude  -c -o dev_entries.o dev_entries.c
cc -Lmft -lmft  bmap.o libbmap.o dev_entries.o  -o bmap
mft/libmft.a: In function `mft_log_perror':
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:297: `sys_errlist' is deprecated; use
`str
error' or `strerror_r' instead
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:294: `sys_nerr' is deprecated; use
`strerr
or' or `strerror_r' instead
cc -Wall -g -Imft/include -Iinclude  -c -o slacker.o slacker.c
cc -Wall -g -Imft/include -Iinclude  -c -o slacker-modules.o slacker-modules.c
cc -Lmft -lmft  slacker.o slacker-modules.o libbmap.o dev_entries.o  -o
slacker
mft/libmft.a: In function `mft_log_perror':
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:297: `sys_errlist' is deprecated; use
`str
error' or `strerror_r' instead
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:294: `sys_nerr' is deprecated; use
`strerr
```

```
or' or `strerror_r' instead
cc -Wall -g -Imft/include -Iinclude  -c -o bclump.o bclump.c
bclump.c:313: warning: missing braces around initializer
bclump.c:313: warning: (near initialization for `options[1].defval')
cc -Lmft -lmft  bclump.o   -o bclump
mft/libmft.a: In function `mft_log_perror':
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:297: `sys_errlist' is deprecated; use
`str
error' or `strerror_r' instead
/UNKNOWN_Binary/bmap-1.0.20/mft/log.c:294: `sys_nerr' is deprecated; use
`strerr
or' or `strerror_r' instead
for i in bmap slacker bclump ; do ./$i --sgml > $i-invoke.sgml ; done
m4 < bmap.sgml.m4 > bmap.sgml
sgml2latex bmap.sgml
make: sgml2latex: Command not found
make: *** [doc] Error 127
```

Appendix C: Forensic Equipment Configurations:

I used two (2) IBM T40 laptops for this analysis – each has some common items (i.e. processors) and then specifics about the loadset and operating system. I have broken this appendix into these two same areas.

Common Characteristics

Processor(s)
Model : Intel(R) Pentium(R) M processor 1500MHz
Speed : 797MHz
L2 On-board Cache : 1024kB ECC synchronous ATC

Mainboard and BIOS
Bus(es) : AGP PCI PCMCIA CardBus USB SMBus/i2c
System BIOS : IBM 1RET36WW (1.07)
Mainboard : IBM 2373EU1
Front Side Bus Speed : 1x 89MHz (89MHz data rate)
Installed Memory : 1023MB

Video System
Monitor/Panel : IBM ThinkPad 1024x768 TFT LCD panel
Adapter : ATI MOBILITY RADEON 7500

Specific Differences Include:

Machine 1 Internal Network Machine //Haliveloclo1[9]

```
Querying information for HALIVELOCLO1...

System information for \\HALIVELOCLO1:
Uptime:                 0 days 3 hours 37 minutes 1 second
Kernel version:          Microsoft Windows 2000, Uniprocessor Free
Product type:           Professional
Product version:         5.0
Service pack:           3
Kernel build number:      2195
Registered organization:   ABC CORP
Registered owner:         ABC CORP
Install date:           03/10/2003, 1:14:58 AM
Activation status:       Not applicable
IE version:             6.0000
System root:            C:\WINNT
Processors:             1
Processor speed:         1.4 GHz
Processor type:          Intel(R) Pentium(R) M processor
Physical memory:         1022 MB
Video driver:           ATI MOBILITY RADEON 7500
```

Machine 2 AIRGAPPED Network Machine //POWERBIRDIE

Output from **'uname –an'** command

Linux POWERBIRDIE 2.4.20-8 #1 Thu Jan 13 17:54:28 EST 2003 i686 i686 i386 GNU/Linux

Logical Storage Devices:

[9] Gathered using PSINFO (www.sysinternals.com)

Output from '**df –ah**' command

```
Filesystem            Size  Used Avail Use% Mounted on
/dev/hda3              32G   20G   11G  65% /
none                    0     0     0   -  /proc
usbdevfs                0     0     0   -  /proc/bus/usb
/dev/hda1             101M  9.2M   86M  10% /boot
none                    0     0     0   -  /dev/pts
none                  504M     0  504M   0% /dev/shm
```

Appendix D: References Used (in order of appearance)

1. SANS - Unknown Binary Media – taken from (http://www.giac.org/gcfa/binary_v1_4.zip)
2. Canadian Evidentiary Act. (http://laws.justice.gc.ca/en/C-5/)
3. Netcat Reference Material and RPM – (http://rpmfind.rediris.es/rpm2html/redhat-8.0-i386/nc-1.10-16.i386.html)
4. XMMS RPM's for Redhat – (http://havardk.xmms.org/dist/xmms-1.2.7-rh8-rh9-rpm/)
5. Google (www.google.ca) - BMAP Search Result (http://lwn.net/2000/0420/announce.php3)
6. Google (www.google.ca) '**bmap 1.0.20**' Search Result (http://build.lnx-bbc.org/packages/fs/bmap.html)
7. DMZ Definition - (http://isp.webopedia.com/TERM/D/DMZ.html)
8. National Institute of Standards and Technology – Definition of Forensic Image (http://www.cftt.nist.gov/DI-spec-3-1-6.doc)
9. Canadian Evidence Act – (http://laws.justice.gc.ca/en/c-5/15821.html),
10. Tool Reference - PSINFO (www.sysinternals.com)
11. Michael Ford - Imaging of Volatile Memory using a Unix machine (http://www.samag.com/documents/s=9053/sam0403e/0403e.htm)
12. Rob Lee - SANS GCFA Training – in class notes on MAC times.